**TII:**

# Operational Amplifiers

**Unclassified**

**1 Hour Conference, W/ 3Hr CAI**

**Safety & Environmental Impact is "LOW"**

# TII: Operational Amplifiers

# Terminal Learning Objective

**Action:** Given the schematic of any of the seven op amps calculate for gain, DC or AC voltage output & DC polarity. In addition answer any question on the operational concepts.

**Condition:** With out references.

**Standard:** Answer correctly 7 of 10 questions, a 70% Minimum.

# TII: Operational Amplifiers

# Introduction

**Much of electronics has changed to Integrated circuits referred to as $Ic_s$, a small to very small Ckt package has set off a wave of research & applications that we enjoy today, such as our computers, cellular phones etc. Most of these consumer items are spin-offs of defense & space exploration technologies. The OP amp is one example and is very common in defense applications.**

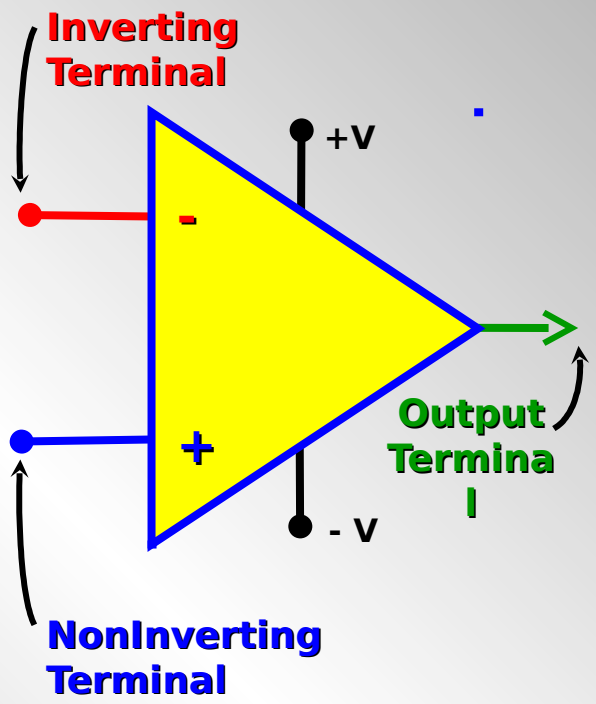
# TII: Operational Amplifiers

## Operational Amplifiers; [Op Amp]

**Symbol; Triangle**

**7 Types of Op Amps;**

1. **Inverting**
2. **NonInverting**
3. **Summing**
4. **Differential**
5. **Common Mode Rejection**
6. **Integrator**
7. **Differentiator**




Package Types

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## Operational Amplifiers; Package Types & Equivalent Ckt.

A. Flat pack

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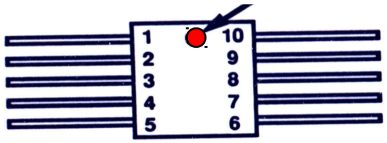


B. Dual-In Line-Package

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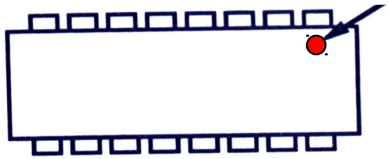
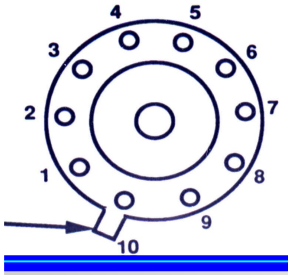


C. TO-5 Can

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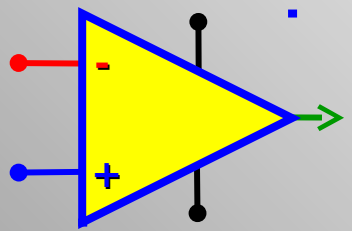
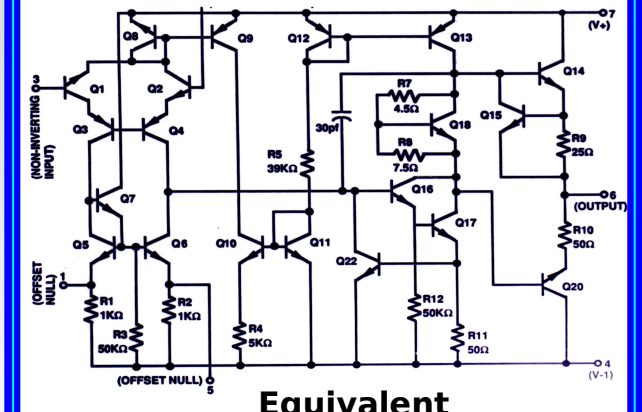
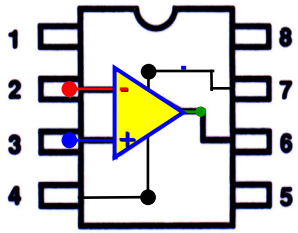
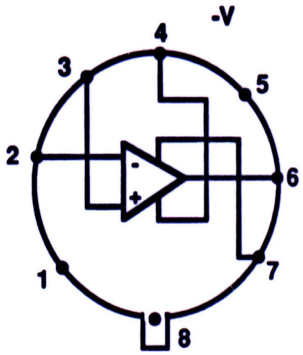



Equivalent Ckt




Dual-In Line-Package DIP

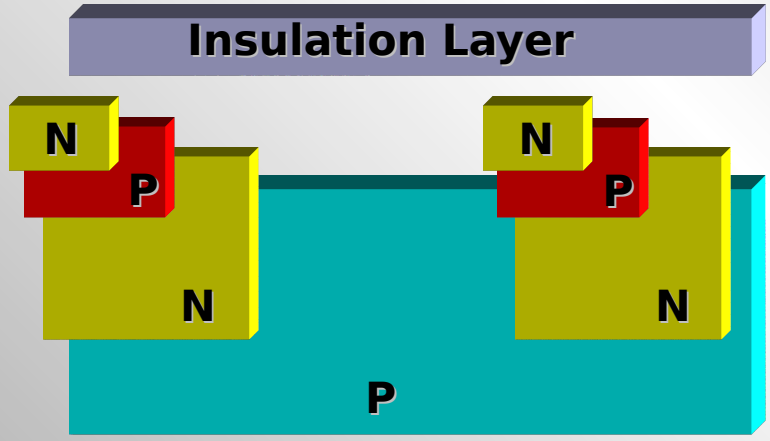


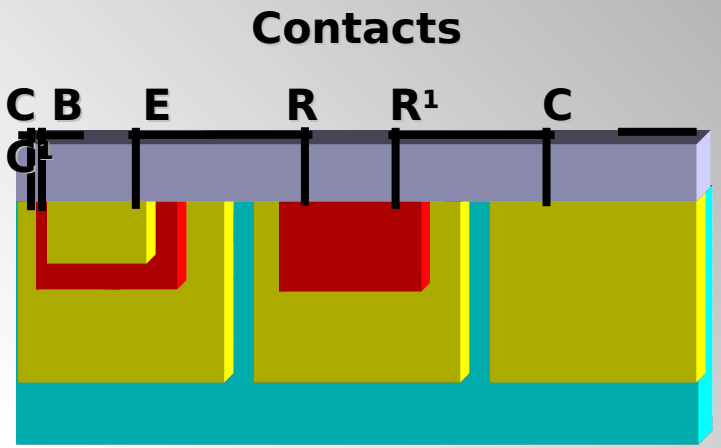

TO-5 Can

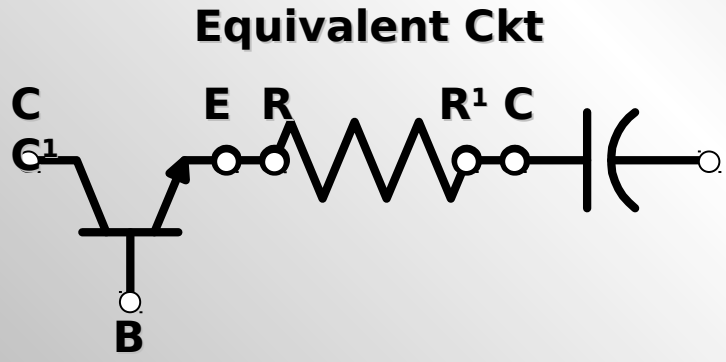
IC Construction

# TII: Operational Amplifiers

## Operational Amplifiers; IC Construction.



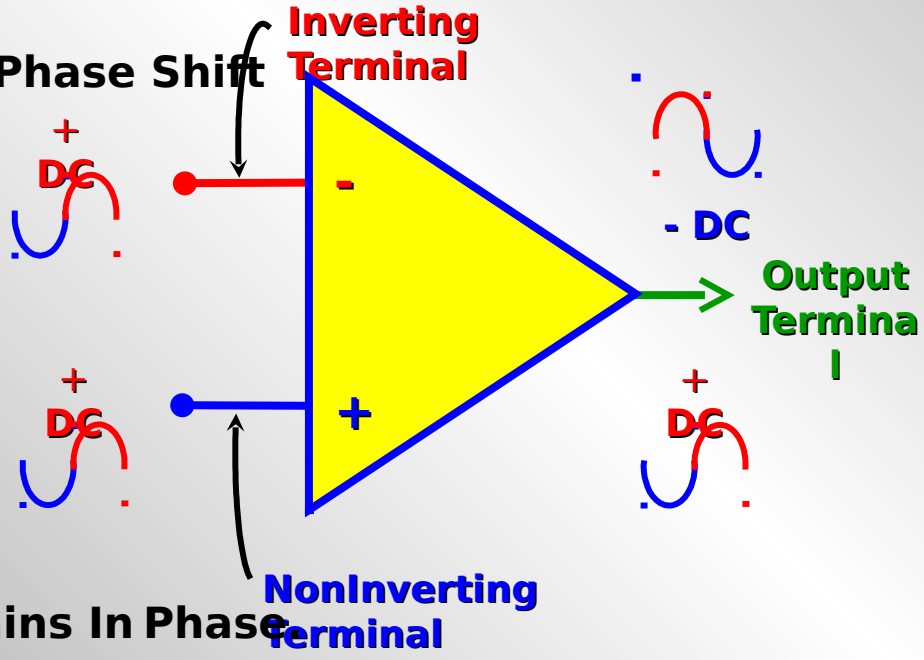

Ivt. & Nivt. Terminals

# TII: Operational Amplifiers

## Inverting & NonInverting Terminals;

**Inverts the polarity of DC voltage; [+ to – ] or [– to +]**

**AC; 180° Phase Shift**




**AC; Remains In Phase**

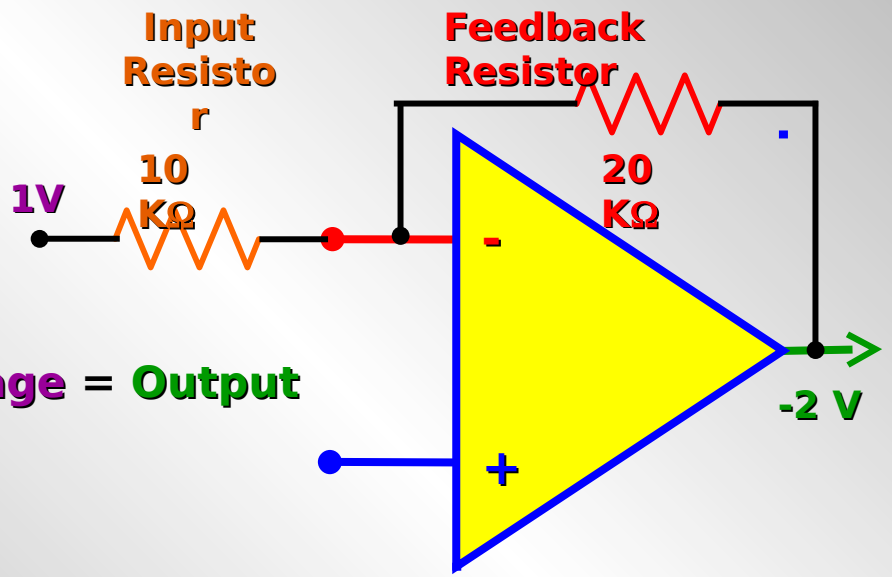
**Polarity of DC voltage <u>Does not</u> change.**

Feedback & Gain

# TII: Operational Amplifiers

## Inverting Amp ; Feedback , Gain & Output Voltage.

Due to the inherent high gain of the Op Amp, external components are added to the Ckt to control the Gain.




RF ÷ R in = Gain X Input Voltage = Output Voltage

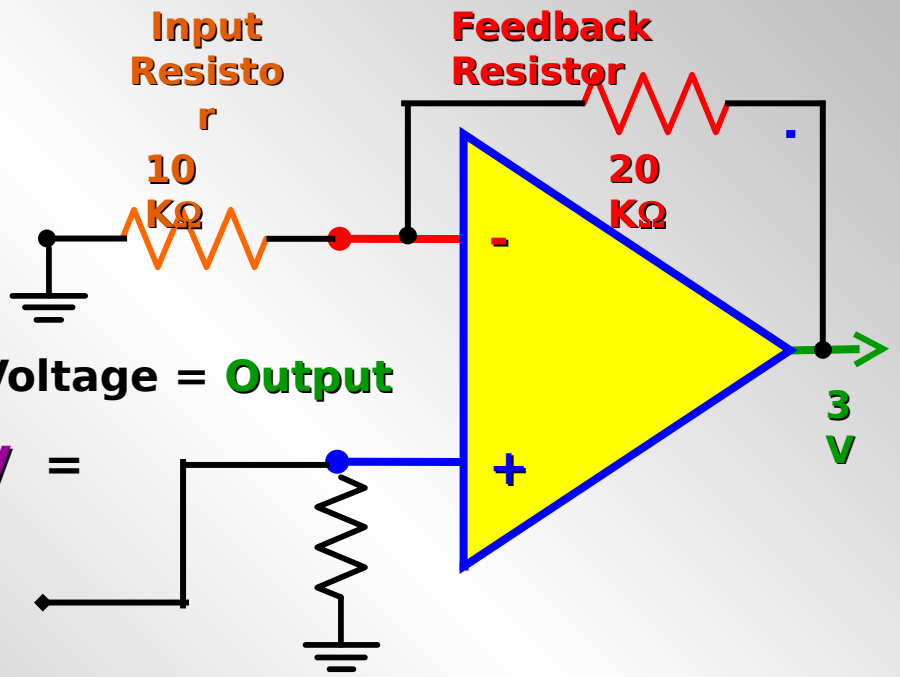
20 KΩ ÷ 10 KΩ = 2 X 1V = -2V

NonInverting Amp

# TII: Operational Amplifiers

## NonInverting Amp; Feedback , Gain & Output Voltage.

Due to the inherent high gain of the Op Amp, external components are added to the Ckt to control the Gain.




RF ÷ R in + 1 = Gain X Input Voltage = Output Voltage

20 KΩ ÷ 10 KΩ = 2 +1 X 1V = 3V

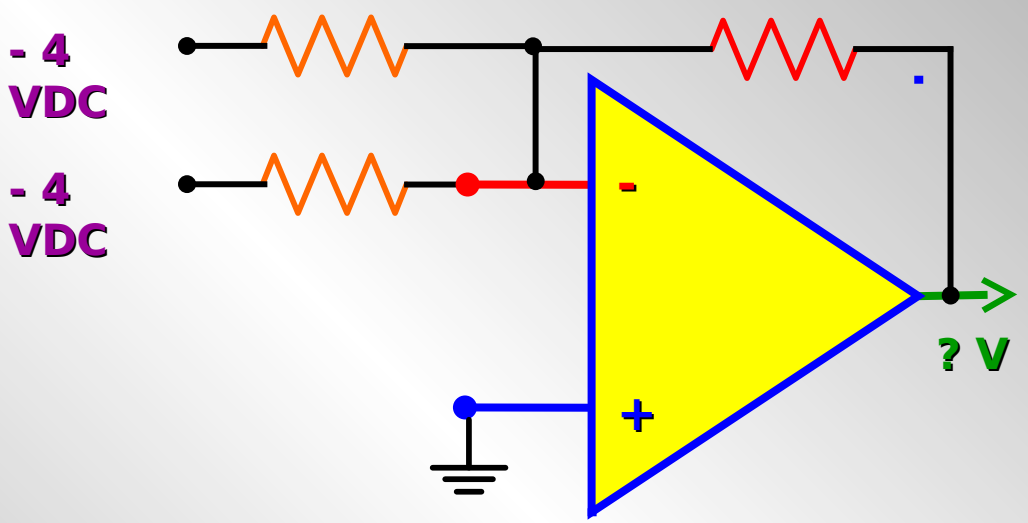
Summing

# TII: Operational Amplifiers

## Summing Amplifier; Inverting Terminal.

**2 voltages of like polarity applied to the same terminal, the output will be the algebraic Sum.**

**On the Inverting terminal the sum will be the <u>opposite</u> in <u>polarity</u>.**

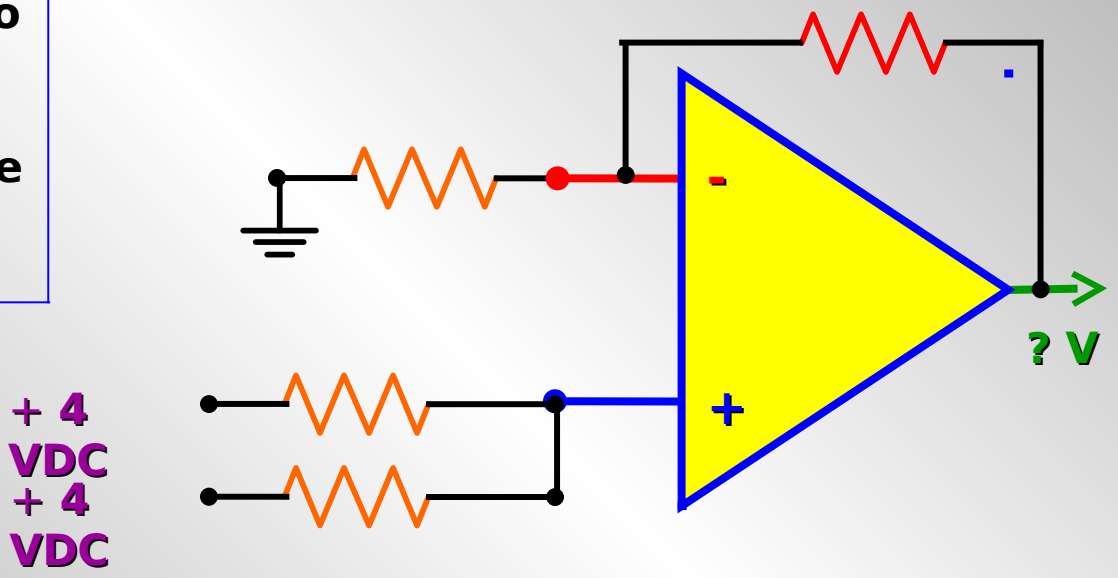



Summing, Non Invert

# TII: Operational Amplifiers

## Summing Amplifier; NonInverting Terminal.

2 voltages applied to the NonInverting terminal the sum on the output, will be the same in polarity as the input.

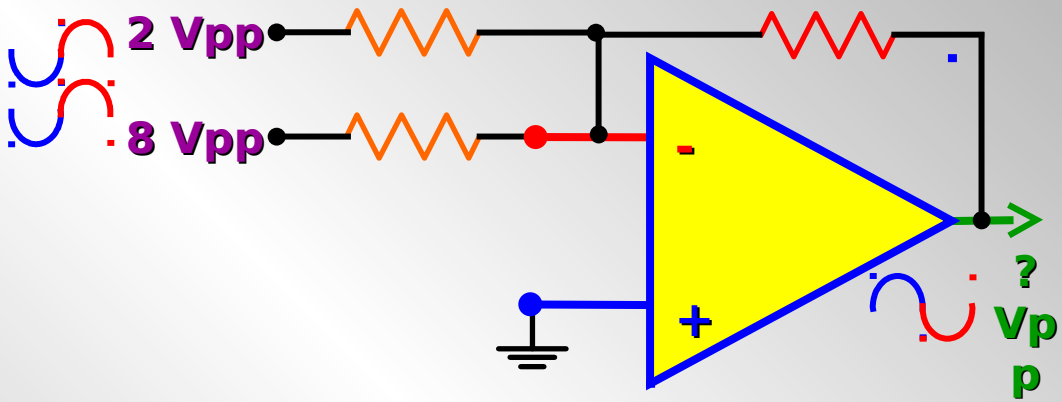



AC, Summing,

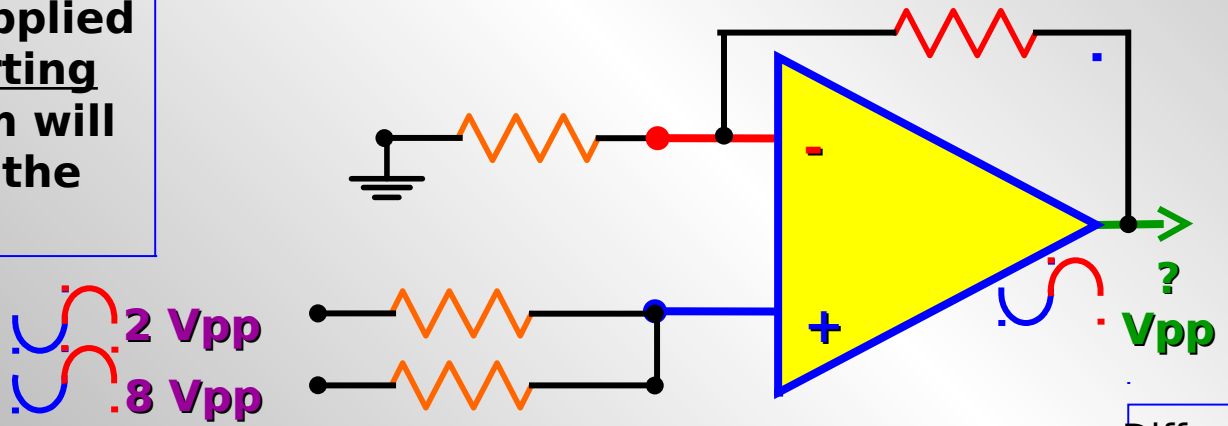
# TII: Operational Amplifiers

## Summing Amplifier; Inverting & NonInverting Terminal.

**2 AC voltages applied to the Inverting terminal the sum will be in 180º out of phase w/ the input..**




**2 AC voltages applied to the NonInverting terminal the sum will be in phase w/ the input.**




Differential

# TII: Operational Amplifiers

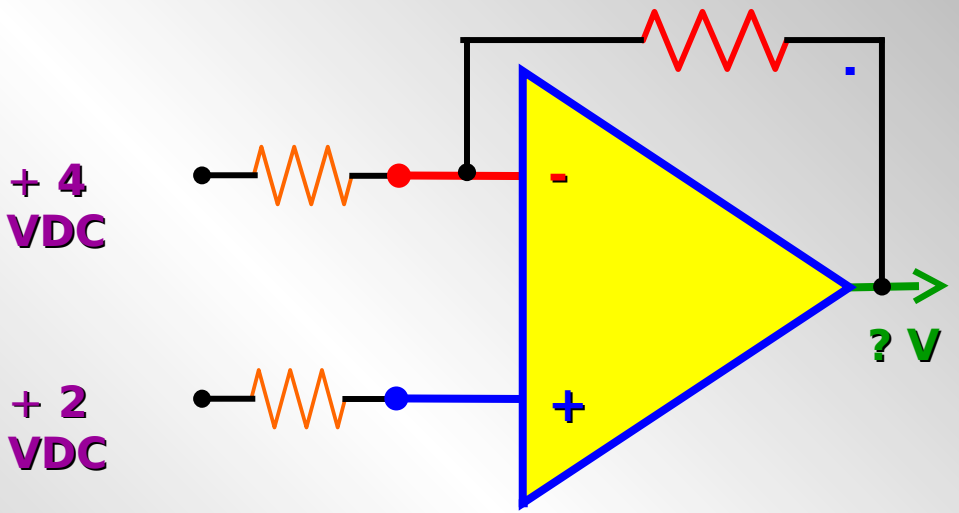
## Differential Amp;

**2 DC Inputs will be the algebraic Difference on the output.**

**The output polarity will be the greater of the 2 input polarities, dependent on which terminal it is applied.**

**If the Greater is on the Inverting terminal then that polarity is inverted.**

**If the Greater is on the NonInverting terminal then that polarity on the out remains the same as the input.**




Differential

# TII: Operational Amplifiers

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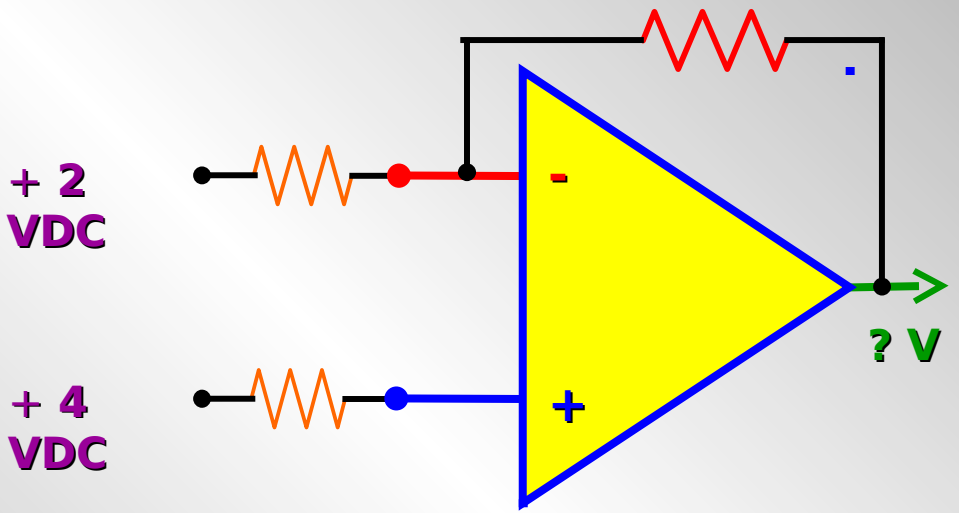
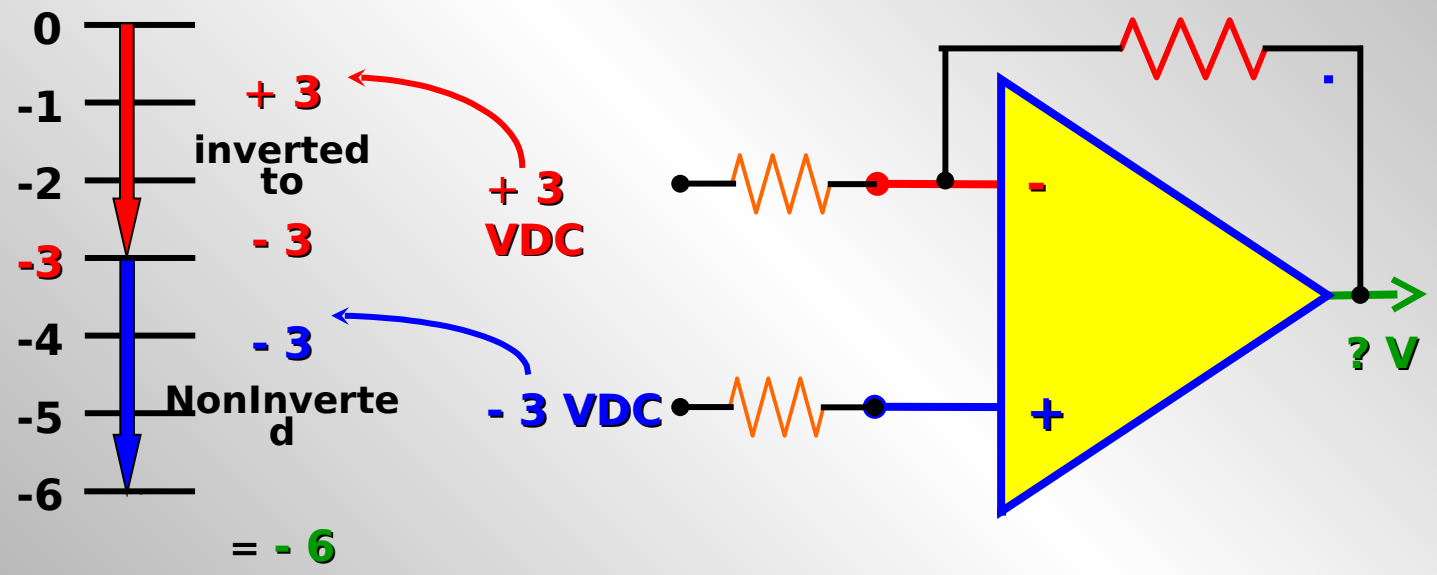



Differential

# TII: Operational Amplifiers

## Differential Amp;

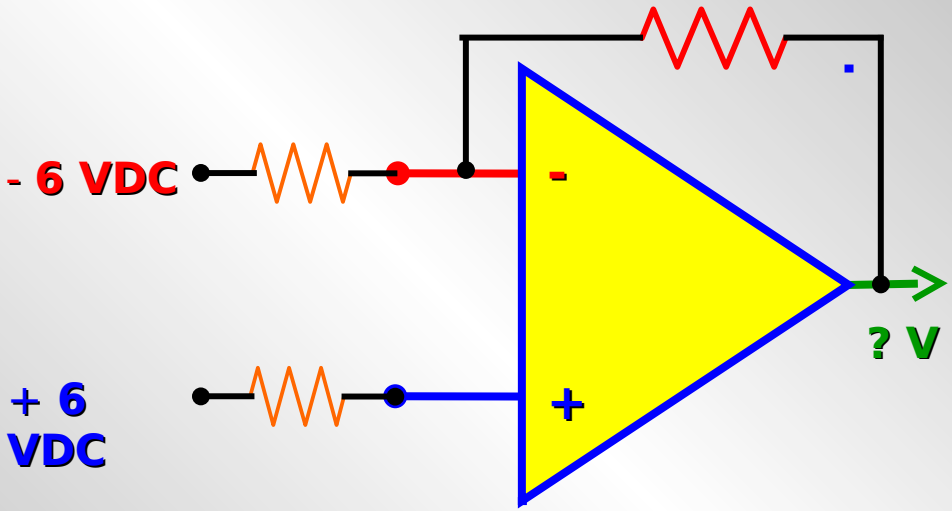



Differential Challenge

# TII: Operational Amplifiers

## Differential Amp;

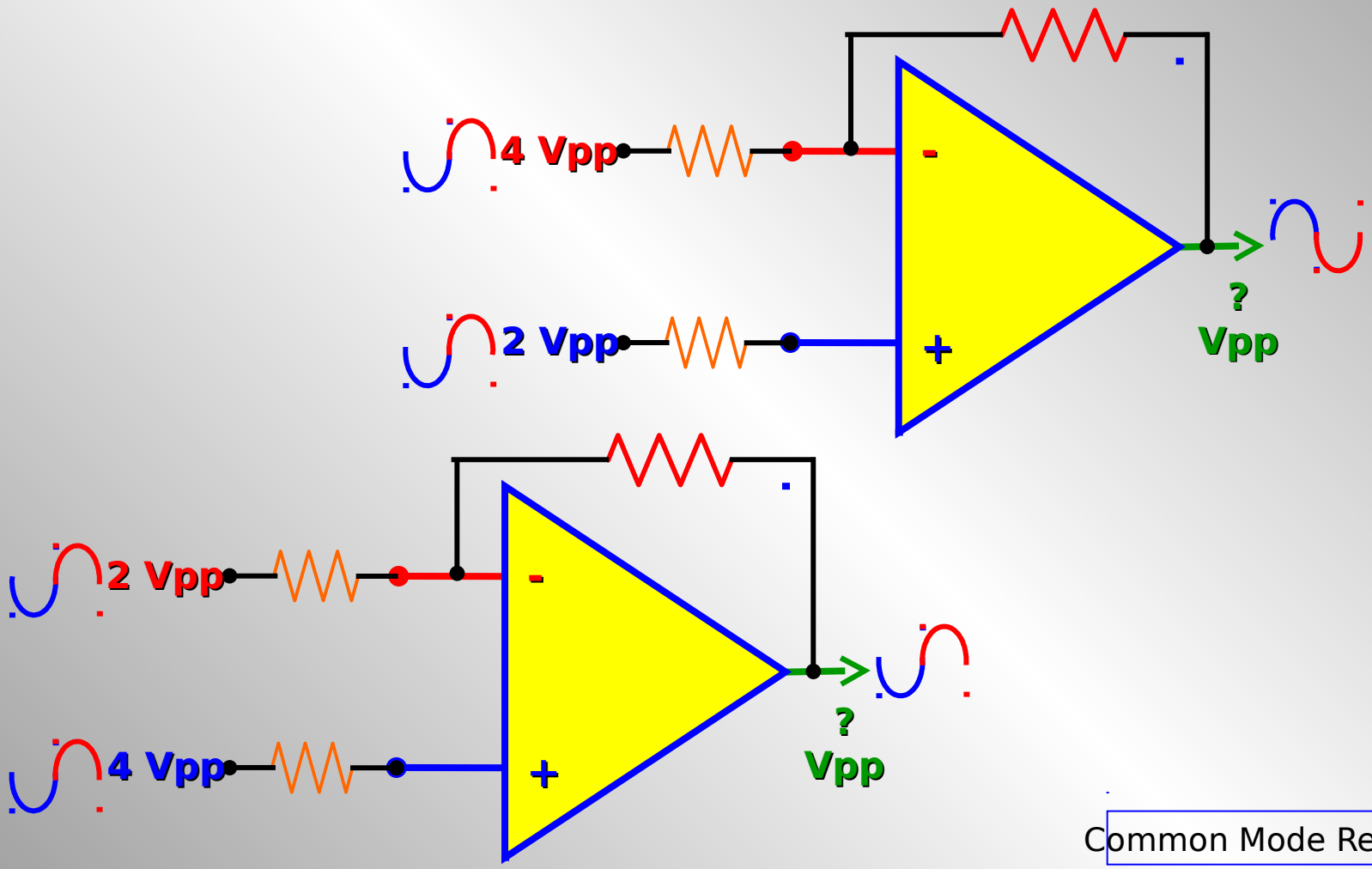
+12
+11
+10
+ 9
+ 8
+ 7
+ 6
+ 5
+ 4
+ 3
+ 2
+ 1
0




AC Differential

# TII: Operational Amplifiers

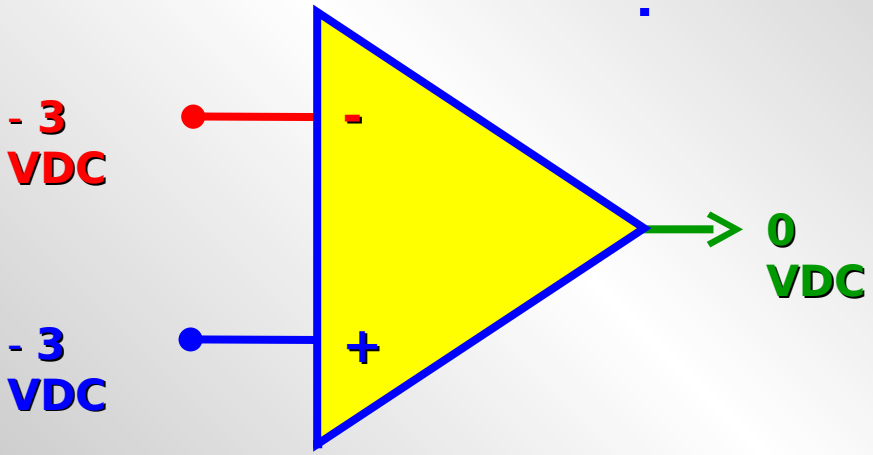
## Differential Amp; AC




Common Mode Rejection

# TII: Operational Amplifiers

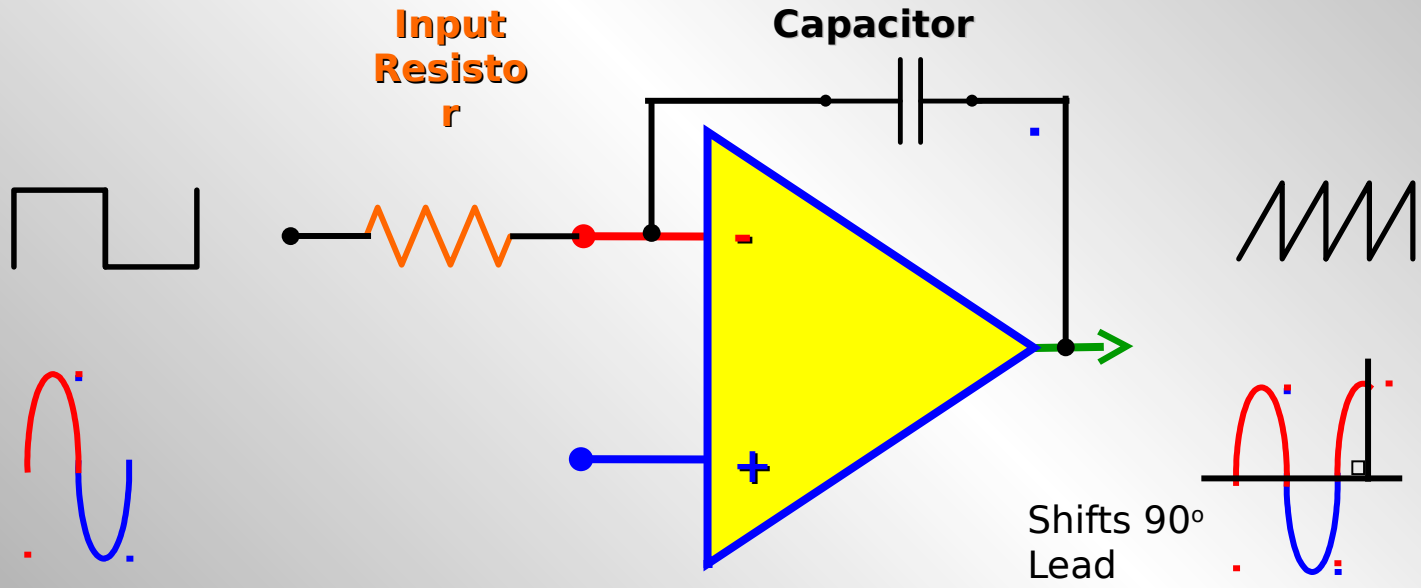
## Common Mode Rejection;




Integrator

# TII: Operational Amplifiers

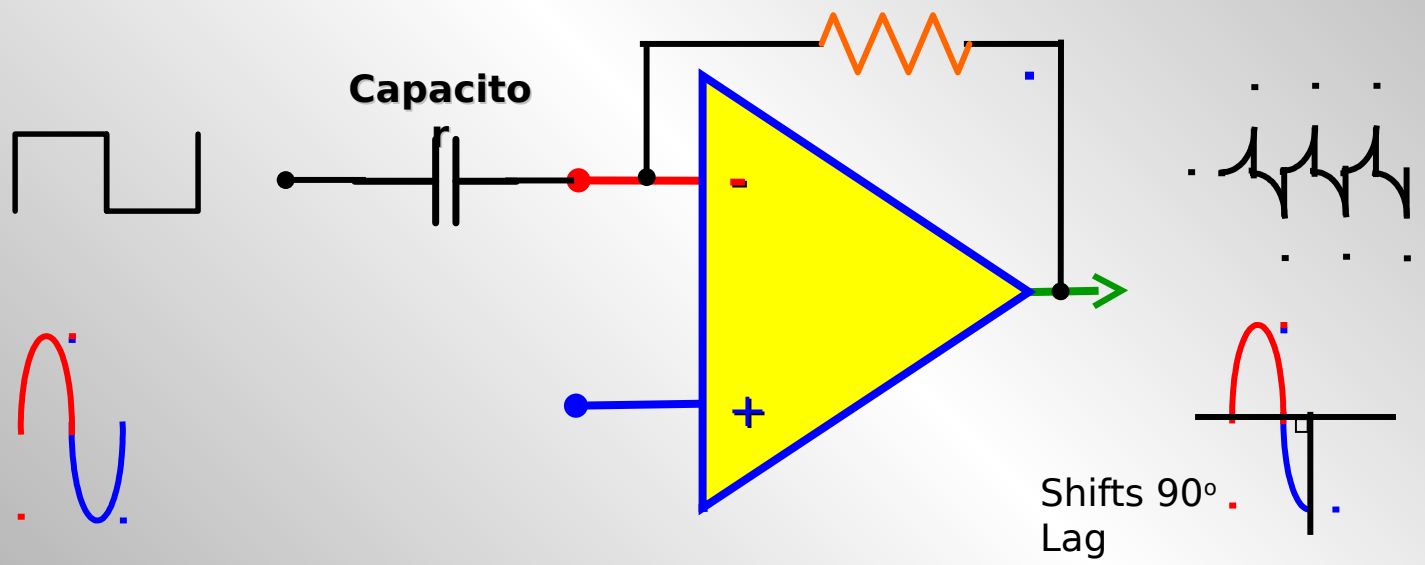
## Integrator Amp; Feedback Resistor replaced w/A Capacitor.




Differentiator

# TII: Operational Amplifiers

## Differentiator Amp; Input Resistor replaced w/A Capacitor.




Review Lessons

# TII: Operational Amplifiers

## Review Questions;

1. What will the output voltage and polarity be when +5VDC is applied to the inverting operational amplifier with a gain of one? _____

2. Draw the Schematic symbol for an operational amplifier.

3. What is the formula used to determine the gain of a non-Inverting operational amplifier? _____

4. Is the feedback [Resistor or Capacitor] built into the amplifier package or part of the external circuit? _____

5. W/ +3 volts applied to the inverting terminal and –3 volts applied to the non-Invert terminal of a differential amplifier, what will be the output voltage & polarity be? _____

Answers

# TII: Operational Amplifiers

## Review Questions;

6. What formula is used to determine the gain of an Inverting operational amplifier? _____

7. What operating mode of the operational amplifier has a capacitor in the feedback circuit? _____

8. What will the output be when 2 VDC & 8 VDC is applied to the Inverting terminal of a Summing operational amplifier?_____

9. What formula is used to determine the output voltage of an Inverting operational amplifier? _____

10. What are the modes of operation of the operational amplifiers taught in this lesson? _____ , _____ , _____ , _____ , _____ , _____ , _____ , _____ ,

Answers

# TII: Operational Amplifiers

**Lesson Test;**

**Lesson Test:**

**Standard: 10 Questions W/in 20 Minutes. 70% Minimum Accuracy. Reference: None.**